

## REMARKS

### Amendments to the Claims

Upon entry of the present amendments, claims 1-15, 17-34 and 36 are presently subject to examination.

Claims 16 is canceled without prejudice.

Claims 1 and 29 are amended to set the lower end of the temperature range at which the hydrocarbon fuel is contacted with a primary desulfurization agent and at which the primary desulfurization agent is regenerated. Support for this amendment is found, *e.g.*, in original claims 14 and 24.

Additionally, claims 1 and 28 are amended to specify that the primary desulfurization agent comprises a metal oxide selected from molybdenum oxide, tantalum oxide, tungsten oxide and combinations thereof. Support for this amendment is found, *e.g.*, in original claims 16-23 and 33, as well as in Example 3 on page 13, where these three compounds were found to perform particularly well. Claims 17 and 18 are likewise amended to reflect that the primary desulfurization agent is limited to the specified metal oxides in the base claim (*i.e.*, claim 1).

Further still, claim 1 is amended to specify that the sulfur is removed by replacing oxygen in the metal oxide with the sulfur from the hydrocarbon fuel to form a metal sulfide and to specify that the primary desulfurization agent is regenerated by replacing the sulfur in the metal sulfide with oxygen to revert back to the metal oxide. Support for this amendment is found, *e.g.*, at page 9, lines 4-10, of the specification, as filed.

Claim 5 is amended to clarify that the higher-boiling fraction and the lower-boiling fraction are separated from “the hydrocarbon fuel after the hydrocarbon fuel contacts the primary desulfurization agent.” Support for this amendment is found, *e.g.*, at page 10, lines 6-26.

New claim 36 is supported, *e.g.*, by original claims 16-18.

Accordingly, the present amendment does not introduce new matter.

Each of the grounds for rejection cited in the Office Action is addressed below, under an appropriate sub-heading.

## **Election/Restrictions**

The United States Patent and Trademark Office requested that the Applicants affirm the election of group I (claims 1-34). Accordingly, Applicants hereby affirm the election of claims 1-34. Consequently, claim 35 is withdrawn, though Applicants reserve the right to claim the subject matter of claim 35 in a divisional or continuation application.

## **35 U.S.C. §112, Second Paragraph**

Claim 5 was rejected on the ground that the “reaction product” referenced therein lacked proper antecedent basis. In response, claim 5 has been amended to substitute a reference to the hydrocarbon fuel for the reaction product. Accordingly, Applicants respectfully request that this rejection be withdrawn.

## **35 U.S.C. §102**

Claims 1, 12, 13, 14, 16 and 24-32 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. 6,184,176 (hereafter, “Khare”).

This group of claims includes two independent claims (*i.e.*, claims 1 and 28). As noted, above, claim 1 has been amended to specify that the primary desulfurization agent is a metal oxide selected from molybdenum oxide, tantalum oxide, tungsten oxide and combinations thereof and that the sulfur is removed from the hydrocarbon fuel by replacing the oxygen in the metal oxide with sulfur to form metal sulfide and also that the metal sulfide is converted back to the metal oxide by replacing the sulfur with oxygen. Claim 28 includes similar limitations.

Khare discloses a sorbent composition that includes zinc oxide. However, the zinc oxide does not appear to react with sulfur to form zinc sulfide in the process of Khare. Rather, sulfur is removed in the process of Khare by “substantially zero valence cobalt” (Khare, Col. 5, line 59, through Col. 6, line 21). Consequently, the sulfur removal process of Khare is not one in which the sulfur from the hydrocarbon fuel is substituted for the oxygen in a metal oxide as specified in Applicants’ amended claims, but rather is one in which a reduced metal bonds to the sulfur.

Further still, the Applicants’ claims specify that sulfur is removed when the hydrocarbon fuel is contacted with the primary desulfurization agent in the absence of added hydrogen. The United States Patent and Trademark Office points out that Khare includes an example (run

number 5 in Example II) wherein no hydrogen was added. However, it is important to recognize that there is no clear indication of sulfur removal in run number 5 because the incoming gas had “about 345 parts per million sulfur by weight” (Khare, Col. 10, lines 21-28), and the resulting gas after one, two and three hours does not appear to stray beyond the margin of error or variation for the gas. Indeed, one of the measurements (after two hours) actually has a sulfur content (*i.e.*, 385 ppm) greater than the “about 345 parts per million” reported for the incoming gas, while the other two measurements are only slightly lower than this level. Certainly, the reading of 385 ppm sulfur after two hours raises serious doubts as to whether any sulfur at all is actually removed by the sorbent in Khare in the absence of added hydrogen. Meanwhile, the high level of sulfur removal in the runs in which hydrogen was added (*i.e.*, runs 1-4, 6 and 7) suggest that the ability of the sorbent to remove sulfur is fully dependent on that added hydrogen in the process of Khare, and there is no suggestion of the oxide-to-sulfide conversion in the process of Khare.

Accordingly, Applicants respectfully submit that the claims, as amended, are novel over Khare and request that this rejection be reconsidered and withdrawn.

### **35 U.S.C. §103**

Claims 2-11, 17-23, 33 and 34 were rejected as being obvious under 35 U.S.C. §103 in view of Khare, alone, or in view of Khare combined with WO 02/22763; U.S. 4,911,823 (“Chen”); U.S. 4,179,351 (“Michlmayr”); U.S. 4,464,252 (“Eberly”); and combinations thereof.

As previously noted, each of the pending claims now specifies that a hydrocarbon fuel is contacted with a primary desulfurization agent comprising a metal oxide selected from molybdenum oxide, tantalum oxide, tungsten oxide and combinations thereof in the absence of added hydrogen to remove sulfur from hydrocarbons in the fuel via conversion of the metal oxide into a metal sulfide and regenerating the desulfurization agent by exposing it to oxygen to convert the metal sulfide back to a metal oxide.

Khare offers no motivation for or suggestion of removing the sulfur via a conversion of a metal oxide to a metal sulfide and then back to metal oxide in a regeneration process. Instead, Khare is directed to the use of zero-valence metal cobalt to remove the sulfur. Of the other cited references, Eberly discloses a catalyst that includes metal oxides. Eberly, however, is directed to

the removal of sulfur from lighter hydrocarbon species in naphtha rather than the removal of sulfur from heavier species in a hydrocarbon fuel. Consequently, the processes disclosed in Eberly appear to be directed to a sulfur-adsorption mechanism that is effective with these lighter species, particularly because Eberly conducts the desulfurization at the relatively low temperature of 350°F (177°C) in the Example (columns 3 and 4) and nowhere suggests desulfurizing at the higher of temperatures of, *e.g.*, at least 350°C, as specified in amended Claim 1.

As noted in the background section of the Applicants' application, sulfur removal from heavy fuels is much more difficult.

There is a well-established hierarchy to the ease with which various organosulfur compounds can be removed from petrochemical streams. Simple aliphatic, naphthenic, and aromatic mercaptans, sulfides, di- and polysulfides and the like surrender their sulfur more readily than the class of heterocyclic sulfur compounds comprised of thiophene and its higher homologs and analogs. Within the generic thiophenic class, desulfurization reactivity decreases with increasing molecular structure and complexity. While simple thiophenes represent the more labile sulfur types, the other extreme, sometimes referred to as "refractory sulfur" is represented by the derivatives of dibenzothiophene, especially those mono- and di-substituted dibenzothiophenes bearing substituents on the carbons beta to the sulfur atom. These highly refractory sulfur heterocycles resist desulfurization as a consequence of steric hindrance that precludes the requisite catalyst-substrate interaction. For this reason, these materials survive traditional desulfurization processes and may poison subsequent processes whose operability is sulfur sensitive.

*Id.*, at page 1, lines 17-29. The process and mechanism described in Applicants' amended claims can effectively remove sulfur from heavy fuels and from their substituents, such as the dibenzothiophene compounds referenced in claim 27. Neither Eberly nor Khare nor any of the other references are directed to removing sulfur from refractory organosulfur compounds in heavy fuels using the recited metal oxides; and, therefore, they offer no motivations for sulfur-removal mechanism described in Applicants' amended claims.

WO 02/22763 also discloses a sulfur removal process involving metal oxides; however it fails to offer any suggestion or motivation for using the recited metal oxides as described in Applicants' amended claims.

Absent a disclosure or suggestion of the metal-oxide to metal-sulfide and back mechanism for sulfur removal and regeneration involving the recited metal oxides, particularly in the absence of added hydrogen gas and at higher temperatures, Applicants respectfully submit that the amended claims are non-obvious over the cited references and respectfully request that this ground for rejection be reconsidered and withdrawn.

### CONCLUSION

On the basis of the foregoing amendments, Applicants respectfully submit that the pending claims are in condition for allowance. If there are any questions regarding these amendments and remarks, the Examiner is encouraged to contact the undersigned at the telephone number provided below.

Respectfully submitted,

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